# Innovation in the use of bamboo as a no conventional material in digital fabrication for artisan entrepreneurs

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**Abstract**

Involve artisan entrepreneurs who work on bamboo furniture, to integrate digital fabrication into their craft, to create better techniques and innovate their products. This paper is about the experience of adapting and innovating the traditional use of this ancestral material, throughout the use of the tools provided in the Fab Lab, to improve the bamboo industry in Perú, hoping that this could apply to other countries that use this material, such as Colombia, Ecuador, China, Japan, Korea, etc. Our methodology implies the use of the shopbot and laser machine to create a bamboo joint. We have centered our work around the joints because through the research we have found this is the weakest point in all bamboo constructions, either furniture or architecture. It is also the most expensive part, and it usually involves materials that are difficult to manage for small enterprises. This product is presented to artisans in a workshop, where they can add value to their own products by using this joint, to save time and work and get acquainted with digital fabrication and its benefits to their work. The main goal of this paper is to demonstrate the social impact the fab lab can make on the community of artisans and how this can replicate in different countries with the same situation.

**Keywords**

digital fabrication, bamboo, shopbot, artisans

## 1 Background

In the past years, digital fabrication has become more popular and affordable, through fab labs around the world that have allowed people from different backgrounds to reach top technology to take ideas and make them real. In Perú we have six Fab Labs, and each one of them have a different format and approach of digital fabrication, to allow creation and education in all sorts of levels. Despite this positive outlook, there is still a lot of work to be done. In Perú we have an ancestral tradition in crafts, and a lot of creative artisans that could benefit from the incorporation of digital fabrication. One of the main issues with the work made by artisans is that the tools they use are old dated and standard –circular saw, drill, reciprocating saw, etc. The demand on wood and bamboo products is growing, but only through innovation small enterprises can really step up to the challenge. In the Fab Lab we can provide the principles needed to improve and create better products, also giving a creative space for artisans to develop their ideas.

## 2 Bamboo and Wood in Peru

Bamboo belongs to the botanical family gramineae is one of the largest and most important for humans, is present naturally into a wide geographical distribution encompassing the regions of Asian Pacific, the Americas and Africa, with Europe, the only continent which is not found naturally. Peru has about half a

million hectares of bamboo and in the high jungle and the Amazon Basin between natural forests and plantations, and about 50 varieties of this species, according to the association Peru Bamboo. It is the areas with greater amount of this resource the departments of San Martín, Amazonas and Cajamarca and Piura, in these places today is increasing deforestation and the inhabitants live in conditions of limited development. It is a traditional material used in South America since prehispanic times.

Ancient cultures like Moche in the Coastal North of Perú, used bamboo poles to build different kind of structures. Bamboo was found on the burial chambers of Sipan's Lord used for coffins that were used for buried women and children. The Chan Chan complex from Mochica culture was built using bamboo in the walls. Machu Picchu, ancient Inca's city, was hidden during colonial times by bushes of bamboo until it was discovered by Hiram Bingham in 1911. During the colonial time, "quincha" technique, that incorporates bamboo poles, was used for urban traditional buildings. Aproximatedly 430 species of woody bamboos are found in Latin America, Perú has 36 species and 1 subspecie, the majority belongs to genera Chusquea and Guadua (Takahashi, 2006).

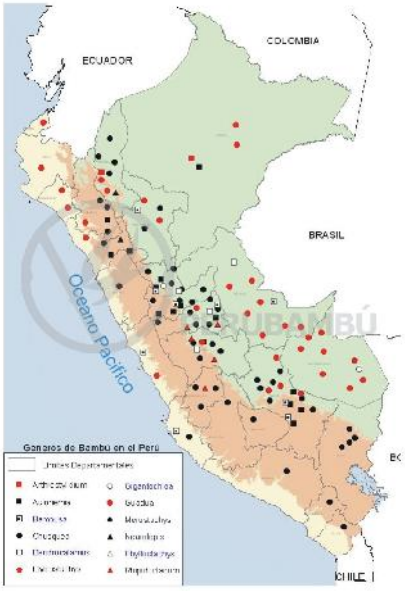


Figure 1: Distribution of Bamboo Species in Perú. Source: Peru Bambu[1]

Despite the potential use of bamboo, it was considered a secondary material, only for ornamental use. "National and local public organizations did not consider these materials in their legislation, with the correspondent exclusion from academic and financial programs and plans in most countries" (Takahashi, 2006). The Construction code for bamboo in Perú was recently approved in 2012, opening new frontiers for the use of this plant in housing projects.

There are efforts by the government through the Ministry of Agriculture and Irrigation by Sierra Exportadora Program[2] to incorporate these people through training in bamboo production chain. In 2011 it was built on a Mini center for Bambu craft,in Aramango City, developing training manufacturing bamboo furniture with primary techniques, with the support of the Association Peru Bambu.

In a study made in Monsefú in Chiclayo made by the Center of Investigation, Training, Advice and Promotion on the North of Perú[3], it was found that most of artisans working on wood are female, with complete school education. They are part of several organizations of artisans in their city, which provide them with training, information about the market, tendencies of design and elaboration and quality of their products. This also brings them the opportunity of participate in craft fairs. From this group, 57% know the bamboo plant and have participated in the elaboration of bamboo products. Also, 47% found necessary the use of machines to elaborate their products, and would be willing to pay for them.

[1] http://www.perubambu.org.pe

[2] http://www.sierraexportadora.gob.pe

[3] http://www.cicap.org.pe

Regarding innovation and training experiences in wood, we find that most of the training revolves around talks from providers about new products and experts. The Center for Technological Innovation of Wood[4] has courses and programs, but although they work with universities, they do not incorporate digital fabrication into their educational programs, using traditional techniques and tools.

In 2013 the demand for wood products increased in Perú, according to National Superintendence of Customs and Tax Administration [SUNAT] and the Peruvian Chamber of Construction [CAPECO][5]. This study also indicates that 65% of Lima citizens choose wood products (floors, doors, windows, furniture, among others) for their homes. According to this study, 96% of businesses dedicated to wood are micro enterprises.

## 3 Academic Experience

From 2011 the course Bamboo Technology in National University of Engineering [UNI] was opened, allowing students to experiment building structures of this material. One of the issues regarding bamboo structures are the junctions. We dedicated a lot of research to this matter, not only to create a junction that worked at a structural level, but also with a good design, and affordable to everybody, and that could have the possibility of being used by standard constructions. Different solutions were made, in steel, fiberglass, rope, bolts and cement.

Figure 2: Junctions made by students from 2011 in the course Bamboo Technology.

In July 2015, students from the Construction Seminar were making a structure for a kids playground and asked the collaboration of a group of artisans to manufacture a wood junction they have designed. The structural properties of the wood helped to make the design stable, but taking into notice that this is going to be used by kids, the junction needed further investigation, for example, polishing the edges to prevent accidents.

[4] http://citemadera.gob.pe

[5] Found on Gestión. 14-03-2015 [http://gestion.pe/economia/65-limenos-prefieren-productos-madera-sus-hogares-2126136]

During the Fab Academy in 2013, a first attempt of cutting bamboo in the Shopbot was made. Despite the fact that the milling was successful, the bamboo pole needed to be fastened to the table, a task that required a lot of effort, time and special tools. In addition to this, a secure method for ensuring the pole was stable was not found. Making a balance between using the Shopbot and a Circular Saw, we found that it was safer to cut the bamboo pole using the latter.

Figure 3: Collage of photographs taken during the test made in Fab Academy 2013 by Vanessa Montezuma.

## 4 Press-fit Bamboo Furniture

After a closer look at the furniture made by artisans, we decided that for a first prototype it would be best trying to improve the models that already existed. We began creating three types of junctions and then build a bench based on one of those junctions. Four factors were taken in to consideration for the design and material selection: it had to be functional, economic, sustainable and easy to assemble.

Figure 4: Press-fit bamboo furniture.

### 4.1 Implementation

We tried to make the junction with two types of materials: recycled wood board and MDF board. We chose a 10 mm recycled wood board to build the first set of junctions. We found that although this material is a good choice for the environment, did not work for easy assembling. When cut the board

begins to tear apart. The finish of the edges was not prolix. The material itself was not good for making a junction that was going to be disassembled many times.

Figure 5: A piece of the junction, made with 10mm recycled wood board.

For the second attempt, we chose a 6mm MDF board. We found that this was the best material that could allow us to make more small and delicate pieces. The finish on the edges is better for furniture that was going to be disassembled many times. Due to usage limitations, we manage to use the Shopbot, but no the Laser Machine because it is on maintenance. Since this was an investigation project made in the Fab Lab UNI, we had to use the machines available there. For further explorations of design, we will be using the laser machine when available. Bamboo poles where obtained from a local distributor. We manage to obtain poles that were recycled from a previous use as scaffolding.

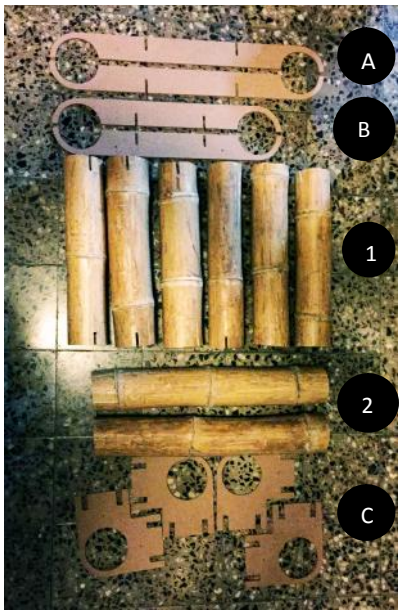


Figure 6: Set of pieces from the Press-fit bamboo bench.

## 4.2 Assembling

The final model is made of MDF board cut joints and sticks, bamboo poles of 42 cms and 44 cms. All junctions are press-fit. Since bamboo poles can vary in diameter, it is to be expected that some parts do not fit perfectly. Making furniture with natural and raw materials require special attention on detail, something that can be improved with feedback from artisans.

The assembling process is described below:

Figure 7: Step by step process of furniture.

| Name | Amount |
|---|---|
| Bamboo Pole 1 | 6 |
| Bamboo Pole 2 | 2 |
| MDF Piece A | 2 |
| MDF Piece B | 2 |
| MDF Junction C | 4 |

Table 1: Number of pieces used in press-fit furniture.

Additional junctions where made for further experimentations with other models of furniture or structure:

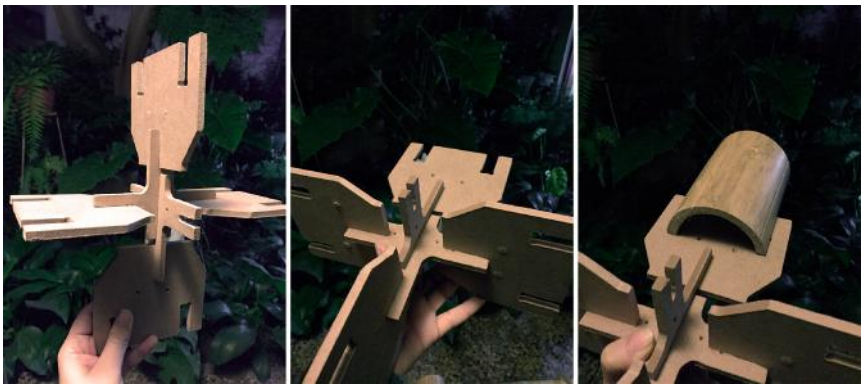

Figure 8: Junction made with 6mm MDF board.

# 5 Workshop

## 5.1 Main Objectives

- To obtain feedback from artisan entrepreneurs that work on wood and bamboo furniture or make some kind of craftsmanship, and contrast their opinions with the experience in the laboratory and in the courses taught at National University of Engineering [UNI].

- To introduce them in to digital fabrication by improving the object they already know and make: furniture of all kind, chairs, tables, benches, etc.
- To present the Fab Lab, what is it about, what things can be made, and a prototype of a bench made with press-fit joints and bamboo.
- We also seek to encourage artisans to create their own models or variations of this bench.

Figure 9: Artisans looking at the cutting of MDF board during the workshop.

## 5.2 About the Participants

We gather a group of artisans that work making and building furniture for offices. From the start we knew that this was a group of people who worked primarily on wood, with a limited set of tools and did not have access to machines like the ones found on the Fab Lab. They work with a set of pre-set models for the furniture they make, and do not engage in any creative process of their own.

The group was composed of men, varying from 20 to 50 years old. They work in the district of Rimac, where the University is located. It was of a great advantage that the artisans came from a location nearby, as we intended to continue with this workshop in order to create a network of artisans involved in digital fabrication.

## 5.3 Methodology

### 5.3.1 Concepts

We look to stablish the relation between digital fabrication and the participants. In this case we needed to explain rather complex terms to an audience with no academic or professional background, so we emphasized the aspect of printing ideas from scratch, inspired by the article wrote by Neil Gershenfeld "How to Make almost anything" from Foreign Affairs: "The aim is to not only produce the parts for a drone, for example, but build a complete vehicle that can fly right out of the printer" (p.45). In many cases, we have found that people tend to believe the Fab Lab is a place for cutting things, not understanding the full concept of what a Fab Lab actually is.
Understanding the concept of "how to make almost anything" was a key element in the dynamic.

### 5.3.2 Stage One: Basic Concepts

Set of questions:

- What is Fab Lab?
- What is Digital Fabrication?
- What can we do / make in a Fab Lab?

We make a 20 minute presentation of the Fab Lab and its programs. We prepared a presentation on the computer regarding three important topics about the Fab Lab in general: what does digital fabrication mean, where did it began and how fast it has grown around the world; what can be done in the Fab Lab;

create, invent, learn, launch a startup based on a prototype. We made emphasis on the learning aspect by talking about the Fab Academy, and what kind of process as students followed to create an object. Also, we commented on the Fab Kids program, as a learning tool for children to expand their imagination.

Objectives:
In this stage the participants:

- Acknowledge the importance of digital fabrication to support the creation of solutions, whether it becomes a startup or just an item for personal use.

Conduction:

- Place participants around a table looking at the presenter.
- Make a presentation on the projector that lasts 15-20 minutes.
- Comment on what kind of things they believe are made in the Fab Lab

### 5.3.3 Stage Two: Use of Bamboo

Set of questions:

- Have you used bamboo?
- Do you know the benefits of using bamboo?
- What do you think of the work made in by students and academic research?

We asked them if they had already used bamboo in any work, and if they knew what kind of things where made with bamboo, presenting a general view of what has been made in Peru.

We also focus on introducing them to the work made with bamboo, academic and as personal research. As part of the Fab Academy, bamboo was cut on the Shopbot machine to make a table (p.3) We explained the goals of this work, and showed the final results, explaining the issues and difficulties adapting a no conventional material to the Shopbot table.

After this we showed the work made by students on Construction Seminar, solutions and issues regarding this type of works, primarily junctions. We made emphasis on the collaborative work made between students and carpenters from the University on the making of a wood junction (p.3).

Objectives:

In this stage the participants:

- Compare the traditional use of bamboo versus the inventions made by students and academic research.

Conduction

- Place participants around a table looking at the presenter.
- Make a presentation on the projector that lasts 15-20 minutes.
- Comment on what they think about the work made by students and academic research.

### 5.3.4 Stage Three: How to make (almost) anything

Set of questions:

- How do I come up with an idea?
- What is the process of making something in the Fab Lab?

We present the method used to create our idea of furniture, how we came up with the concept, how we transform this concept in drawings and finally, how we machine it. First we think about something, an idea, a concept that we want to make real. Then we sketch it on a piece of paper. After that we translate it on a vector based program, were we can continue to modify it. In the end, we can use the laser machine, Shopbot, or 3d printer to make a real prototype. This idea is born when I think I have found a solution to a problem, when I see I can do a better job at something that is already created.

Objectives:
In this stage the participants:

- Acknowledge the process of making an object from scratch.

Conduction:

- Place participants around a table looking at the presenter.
- Give them objects created in the fab lab by the laser machine, 3d printer, shopbot.
- Show in the presentation different software used to transfer sketches.
- Comment on their work: Do they have the chance to come up with ideas for new furniture?

### 5.3.5 Stage Four: Shopbot

Set of questions:

- How does the Shopbot work?
- What kind of materials can it cut?
- How can I benefit from working with the Shopbot?

We show how the Shopbot works by machining a sample of the junction. We presented que Shopbot and its parts and how we were going to cut the MDF board. After translating the object into a series of vector planes, we use two types of software: Partworks and the Shopbot Interface. We explained that Partworks deals with instructions of the diameter of the instruments, thickness of the board, loading the vector plans and assigning them different construction rules: drill, profile, pocket. Shopbot Interface is a program designed to control the machine itself. We went through all this steps to actually show them how much time and work is spent in preparing the work and making it hazard free. Then we proceeded to cut the joints that belong to the press-fit furniture created by us, and gave them the chance to build the joints themselves. After this we presented and assembled the bench. We look for comments of the process, the machine, and the design of the joints.

Objectives:

In this stage the participants:

- To witness on first-hand how the machine works and how it can be helpful to their work.
- To present the press-fit bamboo furniture.

Conduction:

- Artisans stand in front of the Shopbot with glasses and ear protectors.
- Show the participants the MDF board we are about to use.
- Show them what kind of software is used to program the type of technique used: drill, profile, pocket.
- Show them how the machine can be moved manually with the Shopbot interface and what is the process to mark the X,Y,Z axis and the depth of the board.
- After milling the board the participants assemble the joints.

### 5.3.6 Stage Five

Set of questions:

- What did we learned during this session?
- After looking at the things that can be made in the Fab Lab, what modification or new furniture can I create?

Twenty minutes before ending the workshop we gave them a set of open and closed questions about the training given and the possibility, based on what they have learned, to create furniture of their own

with the tools of the Fab Lab. We ask their opinion on the machine and the technique presented on a survey containing seven questions regarding the information received during the workshop, their opinion on the press-fit furniture presented, and what kind of factors should be considered for the design of furniture. Also some personal data like year of birth, grade of instruction and occupation. Full Survey is available on the Appendix 1.

Objectives:

In this stage the participants:

- Reflect on the information given during the workshop.
- Reflect on the technical resources available on the Fab Lab.

Conduction:

- Participants sit down around a table.
- Survey is given to the participants in a spread sheet along with a pen.
- They are left for 15 minutes to answer the survey.

## 5.4 Conclusions

During the workshop we found out that artisans where mainly interested in experimenting on first-hand how the machine worked. Some highlights of this sessions where in Stage Two: Use of Bamboo, because they were eager to learn about the craft made with this plant, and also, because they helped with a project for the students in the Construction Seminar held in the University described earlier in this paper (p.3).

Their comments about related to the difficulties they had making a perfect gap for the bamboo poles. As we discussed earlier, bamboo is not prolix, so it is difficult to adapt. On Stage Three they were very interested on the samples of objects made on the 3d printer we gave them, and asked what kind of material it was. On Stage Four, we found that they were far more interested on seeing the machine in action. We asked for a comparison on what they usually use to cut wood and they told us they knew how to us a router but never had seen something like the Shopbot, that is computer controlled. When we finally assemble the furniture, they told us they already knew press-fit junctions, and that most of modern furniture used them. Some of them thought they were useful when furniture needed to be moved constantly, but did not believe it would be optimal for furniture that needed to be built to last. Also, they think MDF was not a good choice for lasting furniture. They thought that thickness of the MDF could be bigger, to make the furniture more stable. They were eager to contribute on the design of the furniture.

On the results from the survey, they agreed that they wanted more training like this. Also, that press-fit was applicable for manufacturing furniture and was easy to put together, but could use gluing. They also agreed that the technical resources available at the fab lab where necessary for the development of their proposals.

The workshop helped us get to know better the necessities and expectations of artisans regarding the Fab Lab and the importance of better tools for their work. Learning by doing works better for them, so for future workshop programmed for the second week of August we are going to improve the methodology by involving them in the making of an object created by them. This is the first approach made to artisans in the Fab Lab. Other workshops have been made, but were focused on kids, where we participated as volunteers. If we wanted to make a comparison between teaching concepts to kids versus adults, we could say while kids are excited at the moment, a few minutes later this excitement disappears. On the other hand, adults appreciate the usefulness of the machine for their work, and it is easier to explain concepts to them when they already have a background and interest in that topic.

Finally we do not want this experience to be just a couple of workshops, but to integrate artisans in a platform where they could have constant feedback and support, and hopefully creating a social link with the community and the Fab Lab.

**Acknowledgement**

This document could not be possible to make without the help of the artisans who dedicated the time to come and participate from the activities organized.

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# Appendix I: Survey

a) Do you consider that with the training received, you could develop and idea for a solution of new furniture or a modification of existing furniture that could be useful for your own use?

Answers:

- We need more training.
- I think it is applicable to the manufacture of furniture through the press fit whereas the supports thicknesses and of MDF material for a better strength and in some cases could gluing. Example A table.
- Yes, because this method allows to make new furniture designs that not performed.
- Yes, it allows us to make new furniture designs and are very simple to put together and give a better finish and a good presentation.

b) Please describe a proposal for a furniture (indicate problem and solution).

Answers:

- It is a very specific manufacturing and easy to assemble and move to faraway places so it is armed and disarmed.
- A rustic table giving places abiertos- use bamboo and for the preservation of marine varnish applied on the surface with a minimum 03 layers. To fix the furniture can also be used with screws meshed brackets.
- Strengthen the design with something suitable for safety cabinet or using the most suitable material.
- Use synthetic glue in some furniture that can be fixed at home or work. Give the type of finish using paint, lacquer, Barnie, etc. for good presentation.

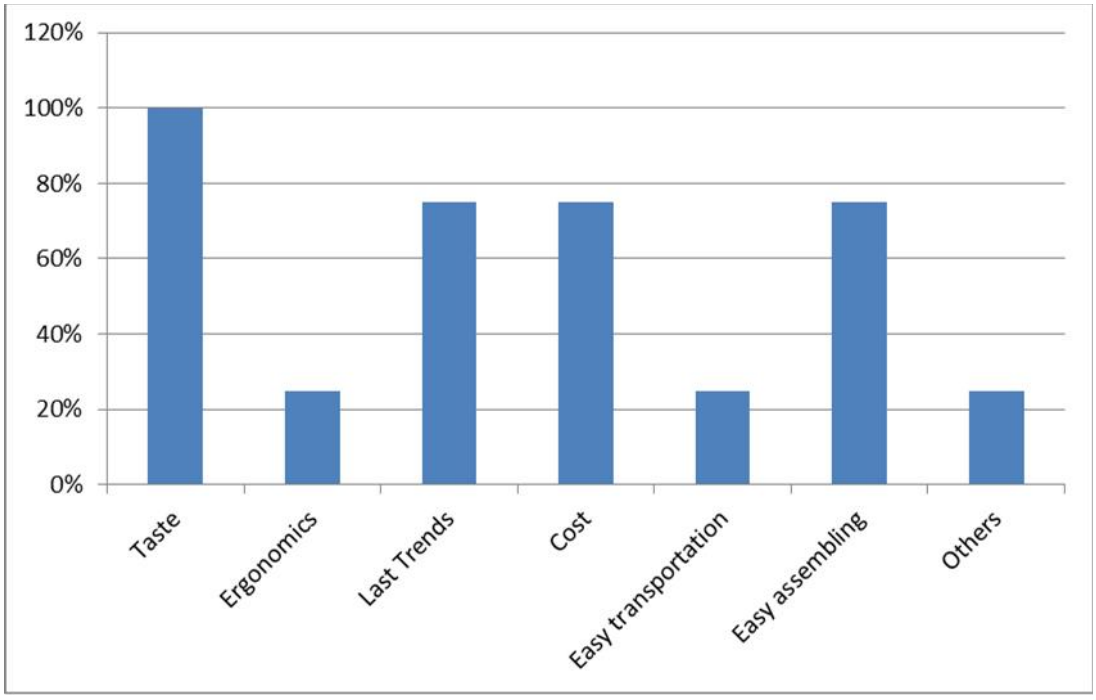
c) Please indicate how much do you agree or disagree with the following statements:

| | **Strongly disagree** | **Disagree** | **Neutral** | **Agree** | **Strongly Agree** |
|---|---|---|---|---|---|
| Talking to others about a problem is really helpful. | 0% | 0% | 0% | 50% | 50% |
| The others helped me by giving advice and suggestions for the improvement of my proposal. | 0% | 0% | 25% | 25% | 50% |
| Others helped me with technical problems related to my proposal. | 0% | 0% | 25% | 75% | 0% |
| Others helped me with feedback about my proposal. | 0% | 0% | 25% | 50% | 0% |
| Confirmation and support from other was really helpful | 0% | 0% | 25% | 50% | 25% |

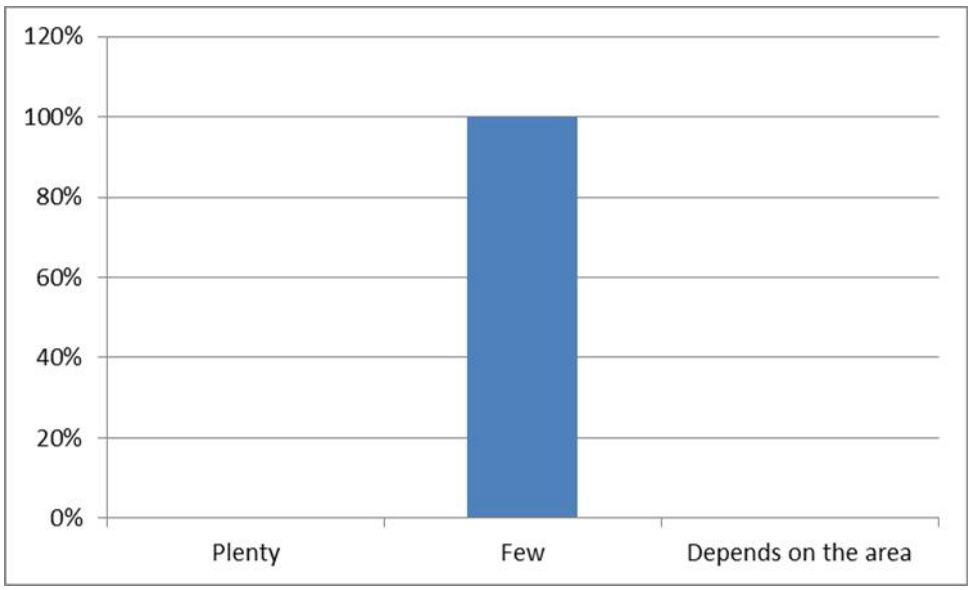
d) Please indicate how much do you agree or disagree with the following statements about the technical resources available in Fab Lab UNI:

| | **Strongly disagree** | **Disagree** | **Neutral** | **Agree** | **Strongly Agree** |
|---|---|---|---|---|---|
| They are necessary for the development of my proposal and prototypes. | 0% | 0% | 0% | 25% | 75% |

e) What factors should we consider when we develop our designs?




f) What volume of demand do you believe exists for this type of furniture? (regarding the prototype presented)



g) Please indicate how much do you agree with the next statements regarding the contribution of bamboo products to the ecosystem.

| | **Strongly disagree** | **Disagree** | **Neutral** | **Agree** | **Strongly Agree** |
|---|---|---|---|---|---|
| By the high density of the plant by hectare | 0% | 0% | 50% | 50% | 0% |
| Its rapid growth | 0% | 0% | 25% | 75% | 0% |
| It does not require pesticides or fertilizers | 0% | 0% | 0% | 100% | 0% |
| Easy to use / build with | 0% | 0% | 25% | 75% | 0% |
| Its a rapid renewable material | 0% | 0% | 0% | 100% | 0% |
| It is a variant to the use of wood, leaving our wood forests intact | 0% | 0% | 25% | 75% | 0% |
| Resistence and durability | 0% | 0% | 25% | 75% | 0% |
| It does not rot from moth | 0% | 0% | 25% | 75% | 0% |

h) Year of birth

i) Grade of instruction: Technical Superior

j) Occupation